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DESIGN AND SIMULATION OF EQUALIZATION BASINS

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DESIGN AND SIMULATION OF EQUALIZATION BASINS

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FOREWORD

Man and his environment must be protected from the adverse effects of pesticides, radiation, noise and other forms of pollution, and the unwise management of solid waste. Efforts to protect the environment require a focus that recognizes the interplay between the components of our physical environment--air, water, and land. The National Environmental Research Centers provide this multidisciplinary focus through programs engaged in

- studies on the effects of environmental contaminants on man and the biosphere, and
- a search for ways to prevent contamination and to recycle valuable resources.

As part of these activities, this report describes two digital computer programs for design and simulation of equalization basins for use upstream of municipal wastewater treatment plants.

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National Environmental
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ABSTRACT

Relationships for sizing equalization basins for smoothing the diurnal variation of dry weather flow into municipal wastewater treatment plants are given. The construction cost for rectangular concrete basins equipped with diffused air and for plastic lined earthen basins equipped with mechanical aerators are estimated. A time dependent digital computer model is developed for simulating biological activity and the consumption of oxygen in equalization basins in which the water level varies diurnally.

DESIGN AND SIMULATION OF EQUALIZATION BASINS

This report describes two digital computer programs for design and simulation of equalization basins for use upstream of municipal wastewater treatment plants. The first program simulates the time dependent performance of the equalization basin by means of numerical integration. In the time dependent program, the equalization basin is always assumed as an earthen pond with plastic lining. The second program described here is a subroutine for the Executive Program[1]. This subroutine (EQUAL) is concerned primarily with computing the size of all equipment and structures and using this information to compute the capital and operating and maintenance cost associated with the equalization basin. The subroutine EQUAL will compute the cost of earthen basins with mechanical aerators as one option and concrete rectangular basins with diffused air aeration as the second option. The following discussion applies to the time dependent program.

The average diurnal dry weather flow (mgd) is supplied as input to the program. The peak diurnal flow is then computed from the following relationship from Orange County[2]:

$$QP = 1.78*QA**0.92 \quad (1)$$

In this equation QP is the peak diurnal flow (mgd) and QA is the average daily flow (mgd).

In this report, mathematical equations will be written in FORTRAN language. The simple rules used are given in the Appendix III.

The dry weather diurnal flow variation is assumed to be sinusoidal. The variation of volume flow delivered to the plant can, therefore, be expressed as follows:

$$Q1 = QA - (QP-QA)*FSIN(6.283*T) \quad (2)$$

The following similar expression for the diurnal variation in BOD concentration is used:

$$BODIN = 200. - 133.*FSIN(6.283*T) \quad (3)$$

Earthen rectangular basins have sides sloping 3/1 and are lined with a plastic liner to prevent percolation. The ratio of basin length to width (RLW) is supplied to the program as input. The minimum water depth in the earthen basin is set at 5 feet. The maximum water depth for the earthen basin is set at 15 feet and the usable volume is the volume of water between the 5 and 15 foot levels.

When QA is supplied as input to the program, QP is computed from equation (1) above, and the required usable volume is found by integrating the sinusoidal variation of the influent flow. The usable volume, in millions of gallons, is computed as QP minus QA divided by Pi (3.1416). The relationship between the required usable volume and average flow (QA) is shown in Figure 1. An excess capacity factor of 1.25 is applied to the computed value for usable volume.

The program next computes the length and width of the basin required and the area (AREA) of the water surface at the 15 foot level. The area of the bottom, sides, and a 10 foot strip around the perimeter of the basin is also computed and called SAREA.

If the size of the earthen basin is less than 90 feet square, the program sets the size at 90 feet square.

The dry weather diurnal flow variations for sixteen existing plants were collected and analyzed. This study will be described in detail later in this report, but it was found that the relationship between peak and average flow agreed well with the Orange County data. The form of the diurnal flow variation, however, was not sinusoidal. For the purpose of demonstrating the operation of the time dependent program, however, the sinusoidal variation is adequate.

The ambient air temperature (TA) and the temperature of the influent wastewater stream (TW) are supplied as input. The average water temperature in the equalization basin TL is then computed from a relationship given in Reference 3.

The time dependent program is used to determine the treatment accomplished in the equalization basin and the size of

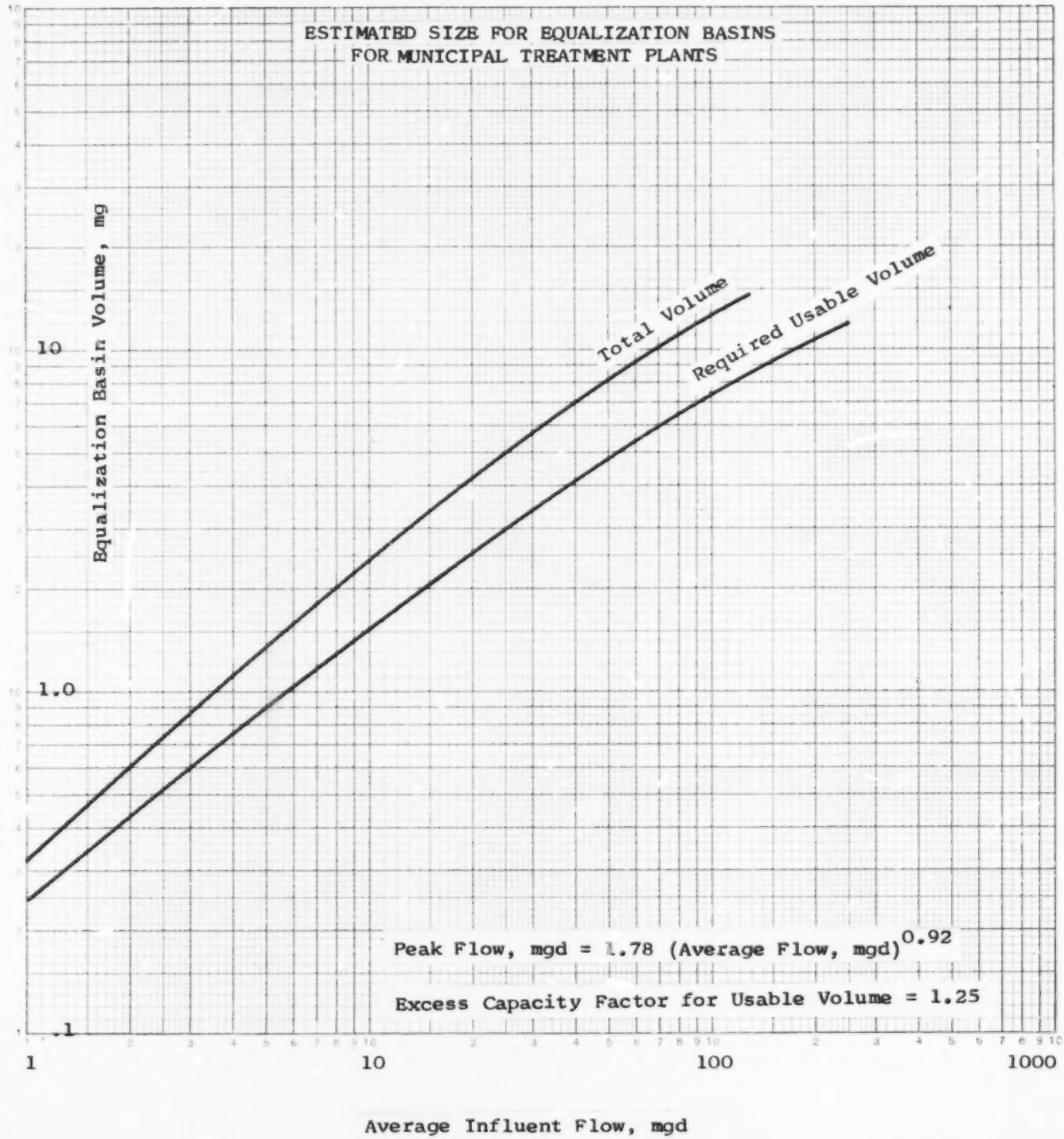

ESTIMATED SIZE FOR EQUALIZATION BASINS
FOR MUNICIPAL TREATMENT PLANTS
Equalization Basin Volume, mg
10
1.0
.1
Total Volume
Required Usable Volume
Peak Flow, mgd = 1.78 (Average Flow, mgd)^0.92
Excess Capacity Factor for Usable Volume = 1.25
1
10
100
1000
Average Influent Flow, mgd

Figure 1

the mechanical aerators needed to maintain a specified dissolved oxygen level in the equalization pond. The rate constants for synthesis (CS), for endogenous respiration (CE) and the yield coefficient (CY) were taken from experiments conducted at Austin, Texas and reported in References 3 and 7 and from Reference 8.

The equalization basin is treated as a completely mixed biological reactor. For example, the rate of change of BOD concentration (S, mg/l) in the equalization basin is computed as follows:

$$SDOT = BODIN*Q1/V - CS*XA*S/CY - Q2*S/V - S(Q1 - Q2)/V \quad (4)$$

In this equation BODIN is the current value for BOD (mg/l) entering the equalization basin, Q1 is the current value for flow entering the basin (mgd), V is the current value for volume (mg) of water in the basin, CS is the rate constant for synthesis, S is the current value for BOD concentration in the basin (mg/l), XA is the current concentration of active solids (mg/l) in the basin and CY is the yield coefficient. Q2 is the current value for flow out of the basin normally set at QA.

Similarly, the rate of change for water volume in the pond and concentration of active solids in the basin are computed as follows:

$$VDOT = Q1 - Q2 \quad (5)$$

$$XDOT = CS*XA*S - XA*Q2/V - CE*XA - XA*(Q1 - Q2)/V \quad (6)$$

Time is expressed in days.

The rate constant for synthesis is corrected for temperature as follows:

$$CAER2 = (5.341 - 2.54*ALOG(XA*V/QI/BODIN))/(150. + S)$$
$$CS = CAER2*(1.08)**(TL-20.) \quad (7)$$

The units for CS are (days x mg/l).$^{-1}$ The rate constant for endogenous respiration (CE) has dimensions days^{-1} and is corrected for water temperature as follows:

$$CE = .125*(1.047)**(TL-20) \quad (8)$$

The time interval used for integration of the biological activity within the equalization basin was 0.01 days. See Appendix I and II for a discussion of kinetics of aerated lagoons.

The program also computes the dissolved oxygen level (mg/l) in the equalization basin when the mechanical aerator horsepower is fixed at some level. The first parameter which determines the power input for aeration is HP, the brake horsepower supplied to the basin. This can be taken as a constant value, or if controls are provided, this can be continuously adjusted to hold the dissolved oxygen level at some set point. The second parameter is the efficiency measure, pounds of oxygen dissolved per brake horsepower hour expended (HPHRO). In running the program, it was found that by using the .01 day integration interval it was possible to compute values for dissolved oxygen (DO) which exceeded the saturation value when the input value for HP was very high. To avoid this problem, the change in DO over the 0.01 day time interval was integrated in closed form assuming the biological activity to be constant. The expressions used are shown below:

```
A1 = HP*HPHRO*ALPHA*1.025**(TL-20.)*24./9.02/8.33/V                    (9)
A2 = .58*CS*XA*S/CY + 1.16*CE*XA                                       (10)
A3 = A1*CSW-A2          A4 = A1 + 01/V                                 (11)
DO = A3/A4 - (A3/A4 - DO)/2.71828**(A4*H)                              (12)
```

The term CSW in equation (11) above is the saturation value for dissolved oxygen (DO) in the equalization pond. CSW is computed as follows:

```
CSW = BETA*RP*DOTW                                                     (13)
```

The saturation value for dissolved oxygen in tap water is computed from the following relationship taken from Reference 6:

```
DOTW = 14.652 - .41022*TL + .0079910*TL**2. - .000077774*TL**3.        (14)
```

The term BETA is a correction factor to take account of the pollutants in the water and RP is a correction for altitude above sea

level at the plant site. RP is computed as follows:

$$RP = (760. - .025*ALT)/760 \quad (15)$$

The term ALT is altitude above sea level at the plant site in feet. ALPHA is a correction on the efficiency of aeration due to pollutants in the water. TL is the water temperature in degrees Centigrade. V is the current volume of the basin in mg. DO is the current value for dissolved oxygen and H is the integration interval in days.

Computed results, using the time dependent program for equalization basins, are shown in Table I. The initial horsepower computed in the program is that required for mixing. This relationship, taken from Reference 7, is shown in Figure 2. When the aerator horsepower was fixed at that value needed for mixing, the DO level in the pond dropped to zero for part of the day for the 3 mgd and 10 mgd cases. At the 10 mgd size, the DO was zero for six out of twenty time points. At the 1, 30, and 100 mgd, the DO level was well above 1 mg/l. The program is equipped for simple proportional control of aerator horsepower where the difference between the DO level in the basin and the set point (1.0 mg/l) is multiplied by a constant (TCl) to find a correction on brake horsepower. The following two equations are used:

$$EDO = SPDO - DO$$

$$HP = HP + TCl*EDO$$

In these equations SPDO is the set point value for dissolved oxygen (DO), EDO is the error in DO, and TCl is the multiplier. The value for TCl used was 30 for 10 mgd, 30 mgd, and 100 mgd. The value for TCl was 10 for 1 mgd and 3 mgd. The value for TCl is not critical but should be roughly proportional to HP. Using simple proportional control, the DO level was held reasonably close to 1 mg/l, about $\pm$ 20%.

The program also integrates the horsepower used over one day and these values are shown in Table I. The peak horsepower demanded, the average horsepower used, and the horsepower required for mixing are shown plotted as HP/mg in Figure 2. The relationship for peak HP is used to size the aerators in the subroutine for the Executive Program.

COMPUTED RESULTS FOR EQUALIZATION BASINS USING TIME DEPENDENT PROGRAM

Average Influent Flow, mgd	Required Usable Volume, mgd	1.25 x Usable Volume, mgd	Minimum Volume, mg	Total Volume, mg	Horsepower Required for Mixing	Peak HP for Bio. Activity
1	0.25	0.31	0.01	0.32	20.0	23.0
3	0.60	0.75	0.11	0.86	32.8	54.0
10	1.53	1.91	0.48	2.40	72.0	102.0
30	3.39	4.24	1.39	5.64	169.2	147.0
100	7.36	9.20	3.49	12.70	381.0	264.0

Average Influent Flow, mgd	Average Detention Time, hours	Average BODIN* mg/l	Average BODOUT** mg/l	Average Active Solids, mg/l	Total BODOUT mg/l	Average Horsepower Used
1	7.68	251	155	53	200	9.2
3	6.88	241	153	53	199	25.1
10	5.76	231	166	47	205	62.9
30	4.51	223	189	35	218	102.2
100	3.05	215	207	12	217	92.4

*Soluble + Particulate BOD-5

**Influent BOD-5 Remaining, Soluble + Particulate

Table I

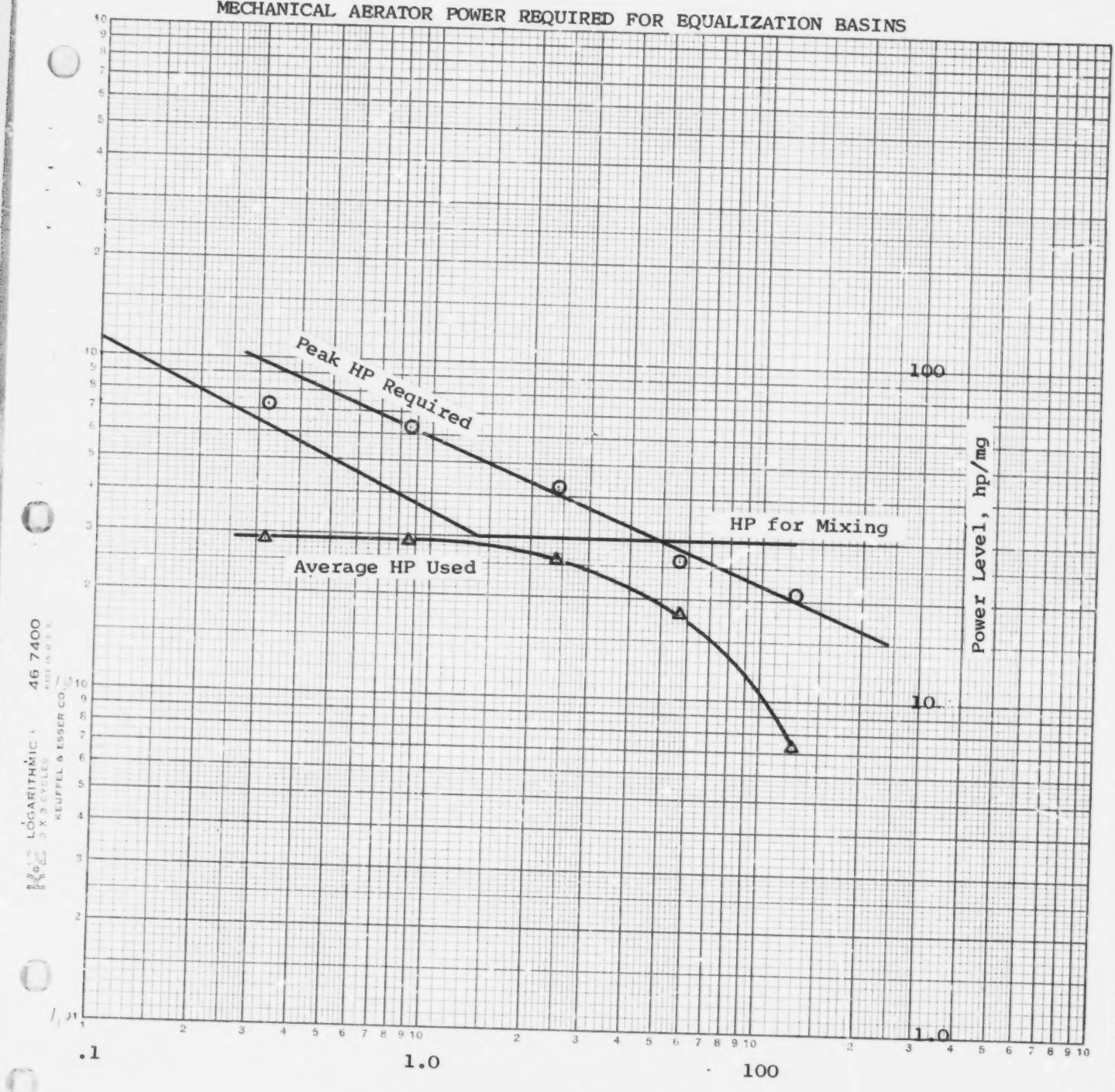

MECHANICAL AERATOR POWER REQUIRED FOR EQUALIZATION BASINS
Peak HP Required
HP for Mixing
Average HP Used
Power Level, hp/mg
100
10
1.0
.1
1.0
100
Volume of Equalization Basin, mg
LOGARITHMIC
3 X 3 CYCLES
KEUFFEL & ESSER CO.
46 7400

Figure 2

The time dependent program also integrates the BODIN, the BODOUT, and the active solids in the basin over one day (24 hour composites). These computed values are shown in Table I. The active solids are multiplied by the factor 0.84 to find the equivalent BOD and added to remaining BOD (BODOUT) to find the total BOD exerted by the effluent from the equalization basin. The removals for BOD computed in this way are seen to be very small. Notice that the 24 hour composite measurements for BODIN do not equal 200 mg/l, but vary with the magnitude of the diurnal flow variation. The detention time for the basin, based on the average flow, is also shown in Table I.

Listings for the two programs; the time dependent program and the subroutine for the Executive Program are shown with definitions of terms in Appendix IV.

The following discussion applies to the subroutine EQUAL for use with the Executive Program. In order to more realistically estimate the equalization basin volume required for smoothing dry weather diurnal flow, diurnal flow patterns from sixteen existing plants were studied. Average daily flow and the peak flow rate are given in Table II. The diurnal flow patterns for each of the sixteen plants were numerically integrated to find the equalization volume needed to make the flow from the equalization basin steady. The results of these computations are shown as required equalization volume in Table II. Plants which have been designed or are now in existence with equalization basins provided are shown in Table II under equalization volume actually used.

The peak flow is shown plotted versus average daily flow in Figure 3. The solid line through the points is the regression line expressed as QP = 1.404*QA**0.988. The dashed line is the relationship used in the time dependent program (eq 1).

In Figure 4, the circled points represent the computed equalization required to smooth the diurnal flow variation. The dashed line shown is the equalization volume required when the diurnal flow variation is assumed to be a sine wave. This volume in mg is

Table II

EQUALIZATION VOLUME REQUIRED IN MUNICIPAL WASTEWATER TREATMENT PLANTS
FOR DRY WEATHER FLOW ONLY

		Average Daily Flow, mgd	Peak Daily Flow, mgd	Required Usable Equalization Volume, mg	Equalization Volume Actually Used, mg
1.	French Creek District Lorain Co., Ohio	7.62	10.35	0.833	1.125
2.	Rilling Road Plant San Antonio, Texas	68.7	92.0	6.76	
3.	Leon Creek Plant San Antonio, Texas	5.94	7.9	0.491	
4.	Fairfield, Ohio	0.833	1.36	0.119	
5.	Garland, Texas	30.0			10.
6.	Odessa, Texas	6.43	9.0	0.783	
7.	Austin, Texas	10.67	15.3	1.34	
8.	Austin, Texas Upstream of Interceptor	17.5			3.0
9.	Freeport, Illinois	4.44	6.0	0.563	
10.	Solon, Ohio	1.28	1.8	0.161	
11.	Rossmoor, Calif. Leisure World	1.3			2.5
12.	Newark, New York	2.23	2.75	0.091	
13.	Walled Lake-Novi, Mich.	2.1			0.315
14.	Hyperion Plant Los Angeles, Calif.	311.	402.	22.8	
15.	Ypsilanti, Mich.	6.38	7.7	0.48	0.68
16.	Grand Rapids, Mich.	43.6	65.0	3.96	

K&E LOGARITHMIC 3 X 5 CYCLES 46 7520 MADE IN U.S.A. KEUFFEL & ESSER CO.

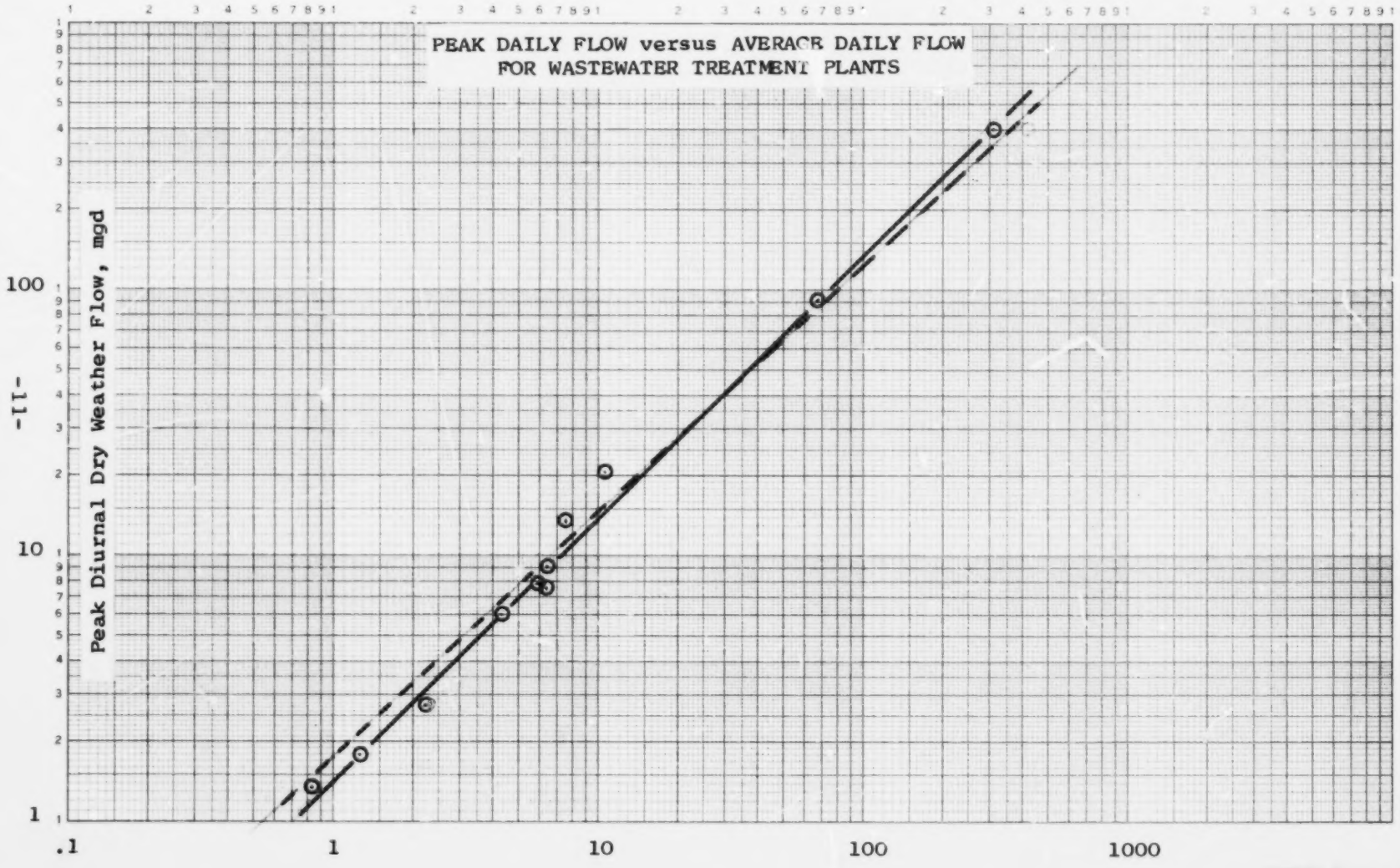


Figure 3

K&E LOGARITHMIC 3 X 5 CYCLES 46 7520 MADE IN U.S.A.
KEUFFEL & ESSER CO.

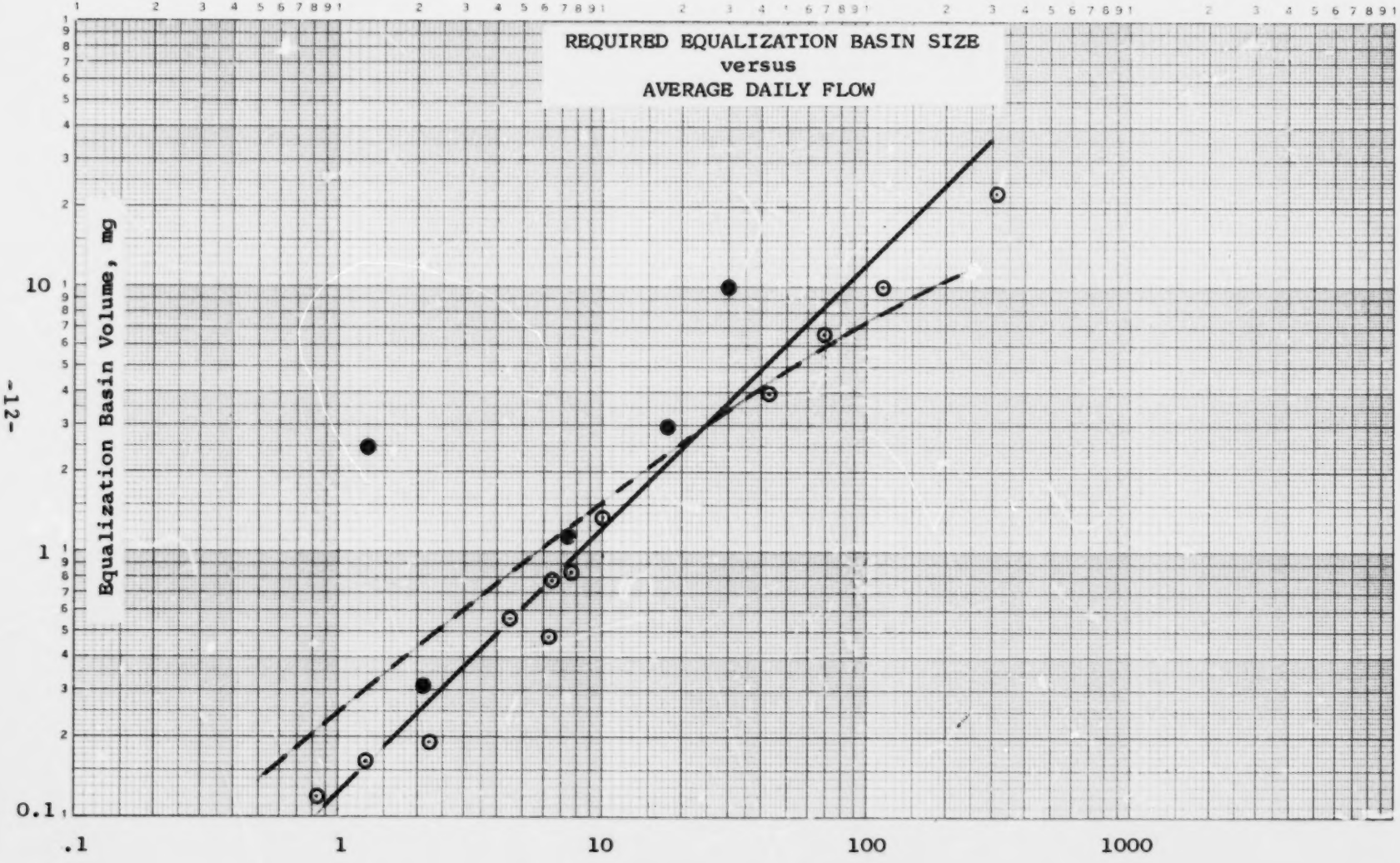


Figure 4

computed as the peak flow minus the average flow divided by Pi. From this graph, it can be seen that the computed equalization volume (assuming sine wave) is high for plants less than 10 mgd. A better fit for the data is a line representing about 12% of the daily volume flow. The 12% rule is shown by the solid line in Figure 4. If the 1.25 excess capacity factor is applied to this estimate, the equalization basin would be sized for 15% of the daily volume flow. This is the rule of thumb used by Johnson and Anderson Associates who have designed several of the equalization basins listed in Table II.

The 12% rule was used in the subroutine EQUAL and provision is made for an excess capacity factor (DMATX (16,N)). A value of 1.25 was used in all computations reported in this report. When a rectangular concrete equalization basin is specified in the EQUAL subroutine, diffused air is used to keep the suspended solids from settling. The diffused air system is sized to provide 20 standard cubic feet of air per minute for each 1000 cu. ft. of equalization basin volume.

When an earthen equalization basin is specified in the EQUAL program, the usable volume is taken as 12% of the daily flow, multiplied by the excess capacity factor (1.25). The same assumptions as those already outlined for the time dependent program are then used to design and cost estimate the earthen equalization basin. Mechanical aerators are always specified with earthen basins. The required mechanical aerator horsepower for mixing and the horsepower required to prevent the dissolved oxygen from falling below 1 mg/l are shown in Figure 2 versus the total volume of the equalization basin. The subroutine EQUAL uses these two relationships for sizing the mechanical aerators. The greater of the two computed values for aerator horsepower is used by EQUAL.

Cost relationships used are from References 4, 5, and 6. The major cost components are the cost of the concrete or earthen basin, plastic lining for the earthen basin, mechanical aerators, effluent pumping, and effluent flow measurement. The cost of the

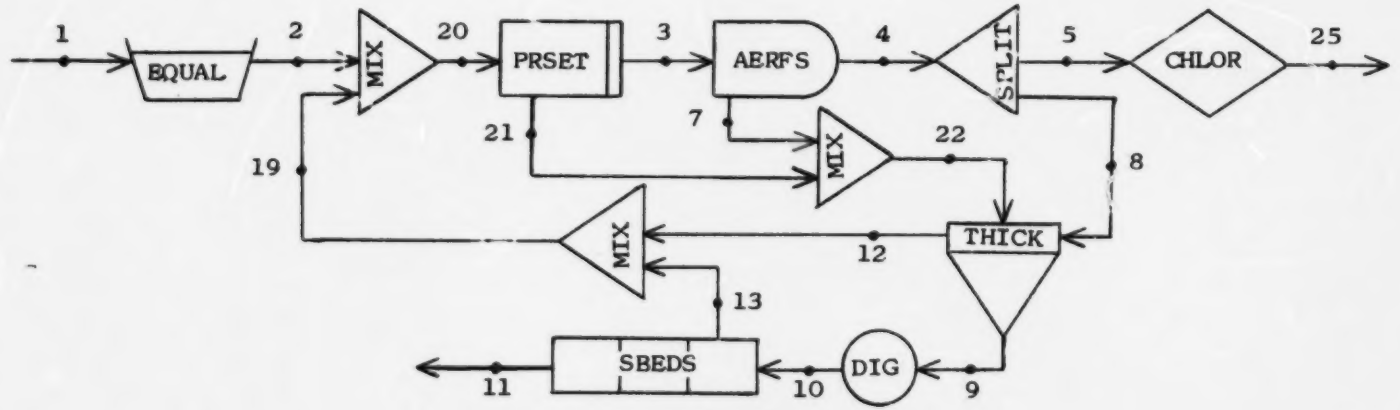
earthen basin is taken from cost relationships given in Reference 4 for aerated lagoons. These costs are expressed as a function of the area of the water surface (AREA) at the 15 foot depth level. The cost of the plastic liner is based on the area of bottom, sides, and a 10 foot strip around the perimeter of the pond (SAREA).

The input (DMATX) and output (OMATX) parameters for the equalization pond subroutine when used as part of the Executive Program are given in Appendix IV. The source card listing of EQUAL and a sample printout from the Executive Program are also given in Appendix IV.

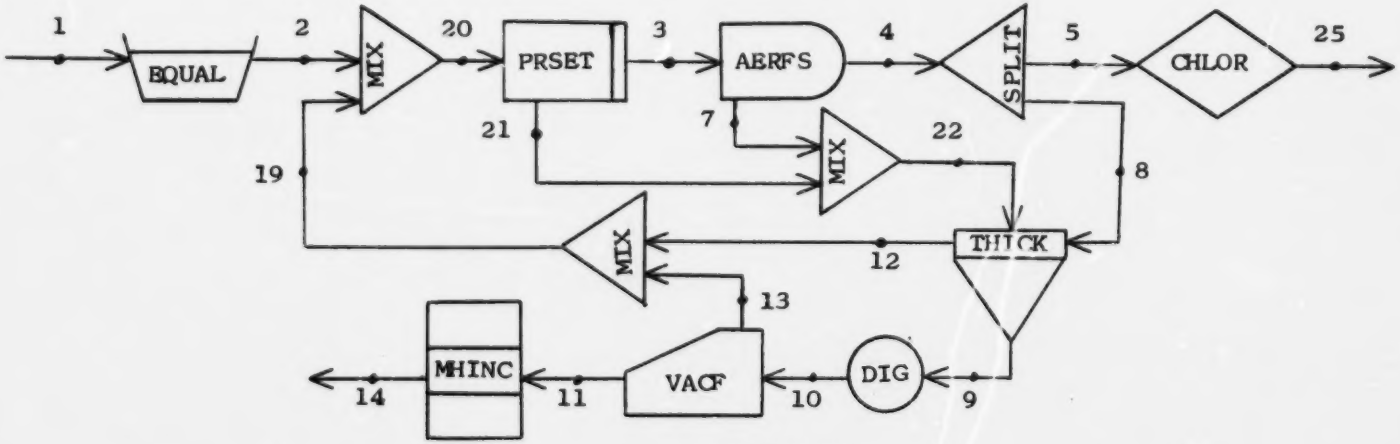
To illustrate the use of EQUAL, the Executive Program has been used to compute the cost of equalization ponds in the two treatment systems shown diagramatically in Figure 5. System 1 consists of equalization ponds (EQUAL), primary sedimentation (PRSET), aerator-final settler (AERFS), gravity sludge thickening (THICK), anaerobic digestion (DIG), sludge drying beds (SBEDS), and chlorination (CHLOR). MIX and SPLIT symbols on the diagram represent stream mixing and splitting. System 2 is similar to System 1 except that vacuum filtration (VACF) and multiple hearth incineration (MHINC) are used in place of sludge drying beds for sludge disposal. Based on previous results, it was concluded that it is generally preferable to use sludge drying beds for the smaller activated sludge plants. At plant sizes greater than 10 mgd, vacuum filtration and multiple hearth incineration for sludge disposal are often preferred. System 1 was evaluated at 1, 3, and 10 mgd, and System 2 was evaluated at 30 and 100 mgd.

The cost of complete treatment plants, including equalization ponds with small impeller mechanical aerators on floating platforms, with large impeller mechanical aerators on stationary platforms, and with concrete tanks equipped with diffused air is shown in Table III. The cost of the equalization unit process alone is also given (Table IV) for each type of unit, and the capital cost includes a proportional amount of the ancillary costs for the plant, such as

WASTEWATER TREATMENT PLANT SYSTEMS USING EQUALIZATION PONDS OR TANKS



SYSTEM 1



SYSTEM 2

Figure 5

COST OF ACTIVATED SLUDGE PLANTS
WITH
EQUALIZATION PONDS OR TANKS

Complete Plant Cost

mgd	A	B	C
1 (SBEDS)	849,591	889,412	890,185
	17.493	17.493	17.884
	35.701	36.555	36.963
3 (SBEDS)	1,399,036	1,444,451	1,534,165
	8.971	8.971	9.573
	18.966	19.290	20.533
10 (SBEDS)	2,818,773	2,894,496	3,206,900
	5.411	5.411	5.899
	11.452	11.614	12.772
30 (MHINC)	10,004,920	10,165,190	10,997,474
	4.620	4.620	4.997
	11.767	11.882	12.854
100 (MHINC)	27,518,836	27,838,136	30,576,288
	3.250	3.250	3.579
	9.148	9.216	10.132

A = Earthen pond with synthetic lining and small impeller mechanical aerators on floating platforms

B = Earthen pond with synthetic lining and large impeller mechanical aerators on stationary platforms

C = Concrete tank with diffused air system

Capital Cost is in dollars (January 1971)
Operation and Maintenance Cost is in cents/1000 gallons
Total Treatment Cost is in cents/1000 gallons (includes amortization at 6% for 25 years)

Table III

COST OF ACTIVATED SLUDGE PLANTS
WITH
EQUALIZATION PONDS OR TANKS

Cost of Equalization Only

mgd	A	B	C
1 (SBEDS)	107,249	148,412	151,269
	2.860	2.860	3.252
	5.159	6.040	6.493
3 (SBEDS)	146,889	193,398	287,376
	1.152	1.152	1.755
	2.200	2.532	3.807
10 (SBEDS)	274,463	351,341	671,369
	.561	.561	1.049
	1.147	1.312	2.486
30 (MHINC)	608,628	769,704	1,611,947
	.447	.447	.825
	.880	.995	1.975
100 (MHINC)	1,524,416	1,844,703	4,602,830
	.307	.307	.637
	.633	.702	1.622

A = Earthen pond with synthetic lining and small impeller mechanical aerators on floating platforms

B = Earthen pond with synthetic lining and large impeller mechanical aerators on stationary platforms

C = Concrete tank with diffused air system

Capital Cost is in dollars (January 1971)
Operation and Maintenance Cost is in cents/1000 gallons
Total Treatment Cost is in cents/1000 gallons (includes amortization at 6% for 25 years)

Table IV

engineering, interest during construction, etc. All capital and operation and maintenance costs for equalization were taken from References 4 and 5. Total treatment cost is the sum of operation and maintenance cost plus amortization cost at 6% for 25 years.

The question of whether equalization basins upstream of activated sludge plants are cost-effective is still unresolved. Although several attempts have been made to study this question experimentally, no conclusive full scale demonstrations are available.

A recent paper by Boon and Burgess[12] showed that in bench scale experiments the 24 hr. composite BOD removals were not significantly different with and without equalization. In this bench scale work, the settler was very effective and the point was made by the authors that the effect of diurnal variations in flow on the performance of the settlers might well be significant.

To investigate the economic significance of this point, the Executive Program was used to compute the cost of several sizes of activated sludge plants equipped with equalization basins to make the flow into the primary settler equal the average diurnal flow. The same plants were then costed without equalization basins but with primary settler and final settler sized on the peak diurnal flow instead of the average flow. The overflow rate used for the primary settler was 1375 gpd/sq ft. For the final settler, the overflow rate was 700 gpd/sq ft.

The cost of activated sludge plants with equalization basin, primary settler, aerator-final settler, gravity sludge thickener, anaerobic digester, sludge drying beds, and chlorination are shown in Table V. Notice that the 30 mgd and 100 mgd plants use vacuum filtration and multiple hearth incineration instead of sludge drying beds. Table VI gives the cost of the same set of activated sludge plants except that the equalization basin is omitted and the primary settler and final settler are sized on the peak diurnal flow with the same overflow rates.

COST OF ACTIVATED SLUDGE PLANTS
USING
EQUALIZATION AND SETTLERS BASED ON AVERAGE FLOW

mgd	Total Plant Cost	Cost of Equalization	Cost of Primary Settler	Cost of Final Settler	Sum of EQ+PS+FS
1 (SBEDS)	890,185	1[illegible]	62,862	97,900	302,031
	17.884	[illegible]	.647	.896	4.795
	36.963	6.493	1.994	2.994	11.481
3 (SBEDS)	1,534,165	287,376	109,159	193,643	590,178
	9.573	1.755	.330	.536	2.621
	20.533	3.807	1.109	1.919	6.835
10 (SBEDS)	2,894,496	351,341	201,904	391,369	944,614
	5.411	.561	.195	.347	1.103
	11.614	1.312	.628	1.186	3.126
30 (MHINC)	10,165,190	769,704	459,182	958,030	2,186,916
	4.620	.447	.133	.242	.822
	11.882	.995	.461	.927	2.383
100 (MHINC)	27,838,136	1,844,703	1,155,621	2,518,346	5,518,670
	3.250	.307	.089	.156	.552
	9.216	.702	.337	.696	1.735

Capital Cost is in dollars (January 1971)
Operation and Maintenance Cost is in cents/1000 gallons
Total Treatment Cost is in cents/1000 gallons (includes amortization at 6% for 25 years)

NOTE: 1 and 3 mgd plants use concrete tanks with diffused air systems
10, 30, and 100 mgd plants use earthen ponds with synthetic lining and large impeller mechanical aerators on stationary platforms.

Table V

COST OF ACTIVATED SLUDGE PLANTS
USING
NO EQUALIZATION AND SETTLERS BASED ON PEAK FLOW

mgd	Total Plant Cost	Cost of Primary Settler	Cost of Final Settler	Cost of PS+FS
1 (SBEDS)	793,890	82,551	130,690	213,241
	15.002	.781	1.133	1.914
	32.017	2.550	3.933	6.483
3 (SBEDS)	1,353,155	147,229	258,963	406,192
	8.060	.423	.686	1.109
	17.727	1.475	2.536	4.011
10 (SBEDS)	2,718,083	265,496	503,697	796,193
	4.985	.248	.430	.678
	10.811	.817	1.510	2.327
30 (MHINC)	9,734,486	581,296	1,178,982	1,760,278
	4.242	.162	.284	.446
	11.196	.578	1.127	1.705
100 (MHINC)	26,583,416	1,368,068	2,904,542	4,272,610
	2.968	.101	.171	.272
	8.666	.395	.794	1.189

Capital Cost is in dollars (January 1971)
Operation and Maintenance Cost is in cents/1000 gallons
Total Treatment Cost is in cents/1000 gallons (includes amortization at 6% for 25 years)

Table VI

This cost data shows that the plant design without equalization is less expensive to build and operate for all size plants. The costs of equalization and settling alone are also given in Tables V and VI. The capital costs include a proportional amount of the ancillary costs associated with the plant. Total treatment cost is the sum of operation and maintenance cost plus amortization cost at 6% for 25 years.

Although these conclusions shed some light on the cost-effectiveness of equalization, it cannot be concluded at this time that equalization should never be used. For example, the relationship between peak and average flow does not apply to all plants. The Washington, D. C. Blue Plains Plant will have a peak/average flow ratio of 2.1 at an average flow of 309 mgd. Also equalization basins which are necessary to store wet weather flow might be profitably used for smoothing the dry weather diurnal flow. Other advantages, such as ease of operation or simpler plant controls might tend to offset the cost of the equalization basin. Plant operating data with and without equalization is needed before a final determination of the cost-effectiveness of equalization can be made.

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APPENDIX I

The wastewater treatment process which most closely resembles an aerated equalization basin is an aerated lagoon. Therefore, available theory for the kinetics of aerated lagoons has been taken as a guide to estimate the performance which might be expected from equalization basins. Based on the estimated relationship between peak and average flow given in the body of this report, the detention time, based on the average flow, will be about 7.5 hours at 1 mgd, 4.5 hours at 10 mgd, and 2.25 hours at 100 mgd. Based on the minimum flow at 1 mgd, the maximum detention time will be about 1.4 days. Therefore, we are most interested in aerated lagoons with detention times short compared to the usual design detention time of about 5 days for aerated lagoons.

The most complete recent work on aerated lagoons is given in Reference 3. In this work, performed cooperatively by the City of Austin, Texas and the University of Texas Civil Engineering Department, both laboratory scale and full scale aerated lagoons were studied. The quality of the effluent stream was reported as filtered BOD. The filtered BOD out of the aerated lagoon was given by the following relationship:

$$\text{Filtered BODOUT, mg/l} = 1/(akt) + b/(ak) \qquad (1A)$$

t = detention time, days
a = 0.65
b = 0.15, days $^{-1}$
ak = 0.143, (days*mg/l BOD)$^{-1}$

The water temperature was generally around 20°C and the data did not show a significant dependency on water temperature. Equation (1A) is shown plotted as the curved dashed line in Figure 1A. Relationship (1A) is for filtered BOD only and the theory presented claimed that the ratio of total BOD to filtered BOD in the effluent is equal to this ratio for the raw wastewater. Reference 7, which gives a more detailed description of the Austin work, showed that

the ratio of total BOD to filtered BOD in the raw wastewater varied between 2.5 and 3.0. Using a mean value of 2.7 for BODT/BODF, the solid curved line in Figure 1A is found. Data from full sized ponds were plotted along with data from laboratory scale effluent data, and these are shown in Figure 1A by the straight dashed lines terminating in a horizontal line at about 5 mg/l. It was stated in the report that filtered BOD values, less than 5 mg/l, were never observed. Therefore, the relationship (1A) was terminated at 4.5 mg/l and replaced by a horizontal line.

The active solids in the aerated lagoon can be computed from the following relationship given in Reference 3.

$$XA = 0.65(BODIN - BODOUT)/(1 + 0.15t)$$

This relationship was used to compute the active solids and the active solids concentration in mg/l was multiplied by the factor 0.84 to convert to an equivalent BOD value. Adding the remaining unsynthesized BOD and the BOD exerted by the active solids gives the upper wavy line in Figure 1A.

The time dependent digital computer program described in the body of this report was used to simulate the performance of aerated lagoons by holding the influent stream fixed and allowing the computation to stabilize. The results of these computations are shown in Table 1A. The results are also shown plotted in Figure 2A. The detention time was varied by holding the volume fixed and changing the volume flow through the aerated lagoon. The water temperature was fixed at 20°C and the BOD of the influent stream was fixed at 200 mg/l. The total BOD in the effluent stream, computed in this way, is shown by the circled points in Figure 1A. The agreement between these two models is clearly good. Notice that in Table 1A the rate constant for synthesis varies by more than a factor of 4.0 between the least and the greatest detention times.

A relationship which is often used in the design of aerated lagoons is shown below:

$$BODOUT/BODIN = 1/(1 + kt)$$

In this equation t is the detention time in days and k is a rate constant given as 0.95 by Marais[11]. The recommended value for k given in the Manual of Practice for Aeration MOP-5, issued by WPCF[10], is 0.5. These two relationships are shown together with the total BOD in the effluent stream from the Austin, Texas study in Figure 3A. It can be seen that the agreement between the Austin results and the Marais relationship is reasonably good at detention time less than about 1.5 days. At 10 days the lines diverge significantly. The line based on k = 0.5 is known to be a conservative design relationship and predicts removals somewhat less than what is actually attainable.

AERATED LAGOON PERFORMANCE BASED ON AUSTIN, TEXAS STUDY

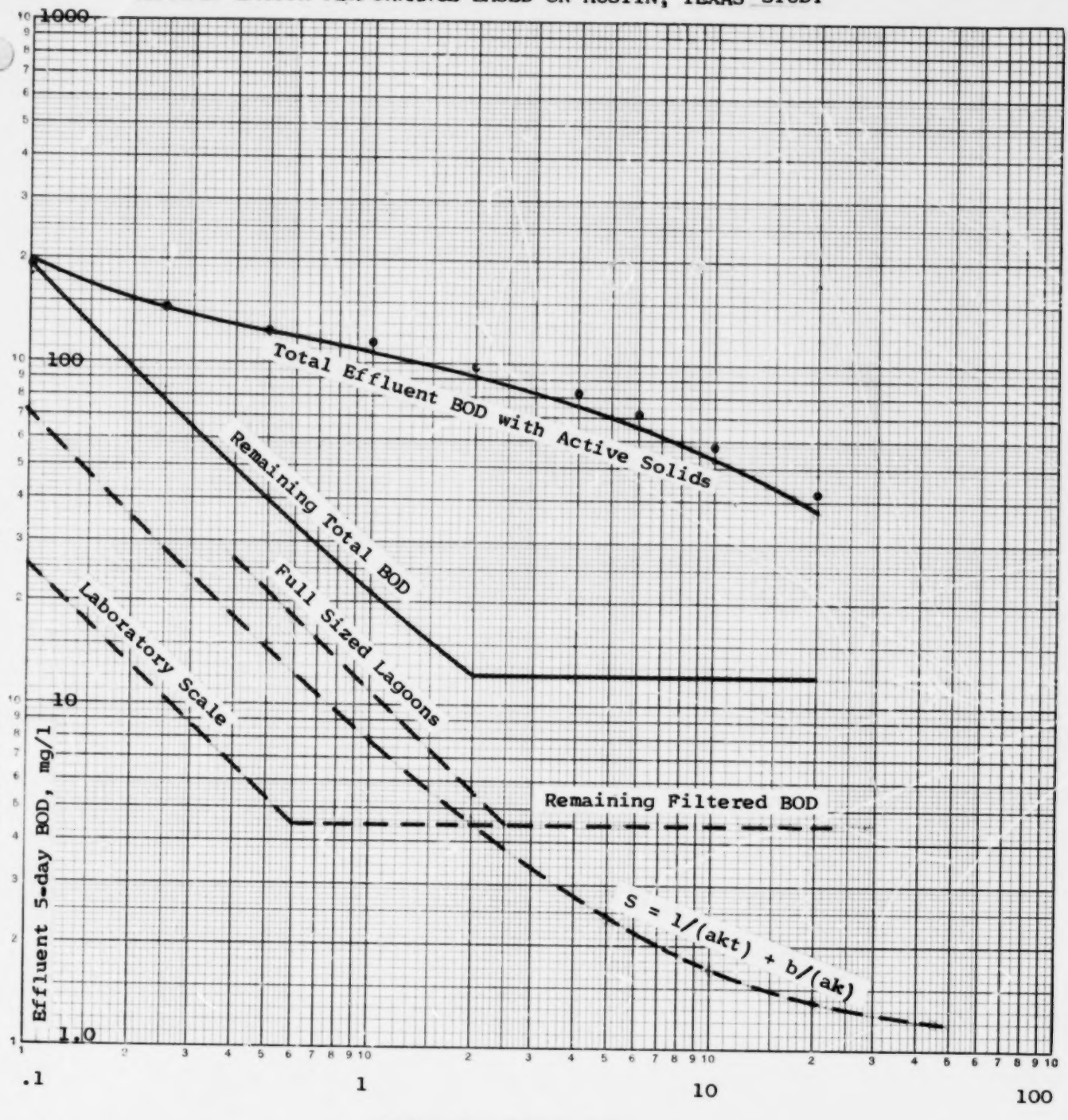


Figure 1A

COMPUTED AERATED LAGOON PERFORMANCE WITH INFLUENT STREAM AND AERATION VOLUME FIXED

Detention Time, days	Active Mass, mg/l	Influent Total BOD Remaining, mg/l	Total BOD in Effluent Stream, mg/l	Rate Constant for Synthesis $(days*mg/l)^{-1}$
0.1	11.7	181.7	191.8	.0555
0.25	72.7	84.7	145.7	.0487
0.50	94.0	46.3	125.2	.0459
1.0	99.2	28.2	111.5	.0399
2.0	93.9	19.2	98.1	.0325
4.0	80.0	14.9	82.2	.0251
6.0	69.0	13.7	71.7	.0213
10.0	53.8	13.0	58.2	.0173
20.0	34.6	13.0	42.1	.0134

Water Temperature = 20°C
Unfiltered BOD in Raw Wastewater = 200 mg/l

Table 1A

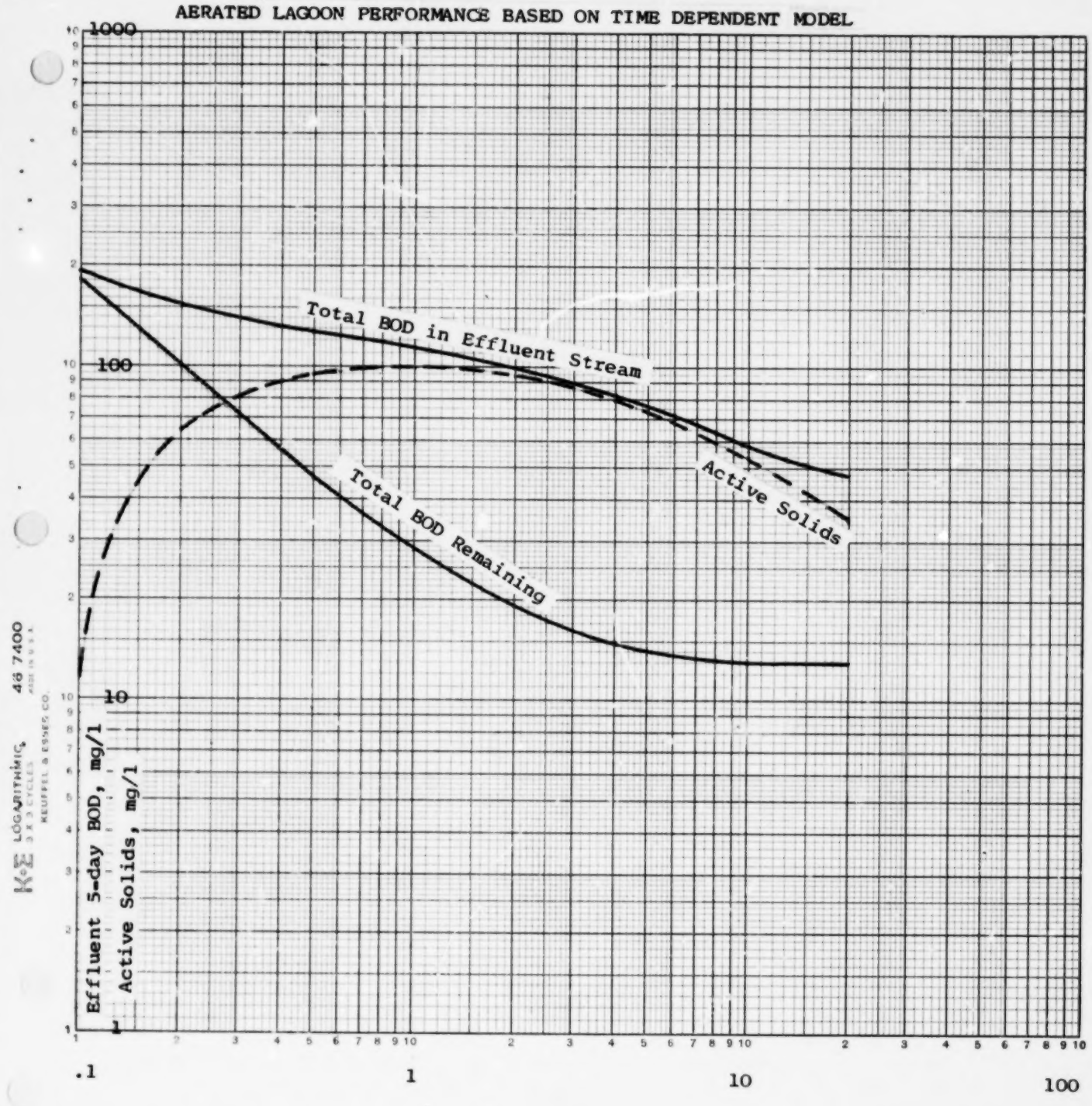

AERATED LAGOON PERFORMANCE BASED ON TIME DEPENDENT MODEL
1000
100
10
1
Total BOD in Effluent Stream
Active Solids
Total BOD Remaining
Effluent 5-day BOD, mg/l
Active Solids, mg/l
.1
1
10
100
Detention Time, days

Figure 2A

COMPARISON BETWEEN THREE RELATIONSHIPS FOR PREDICTING AERATED LAGOON PERFORMANCE

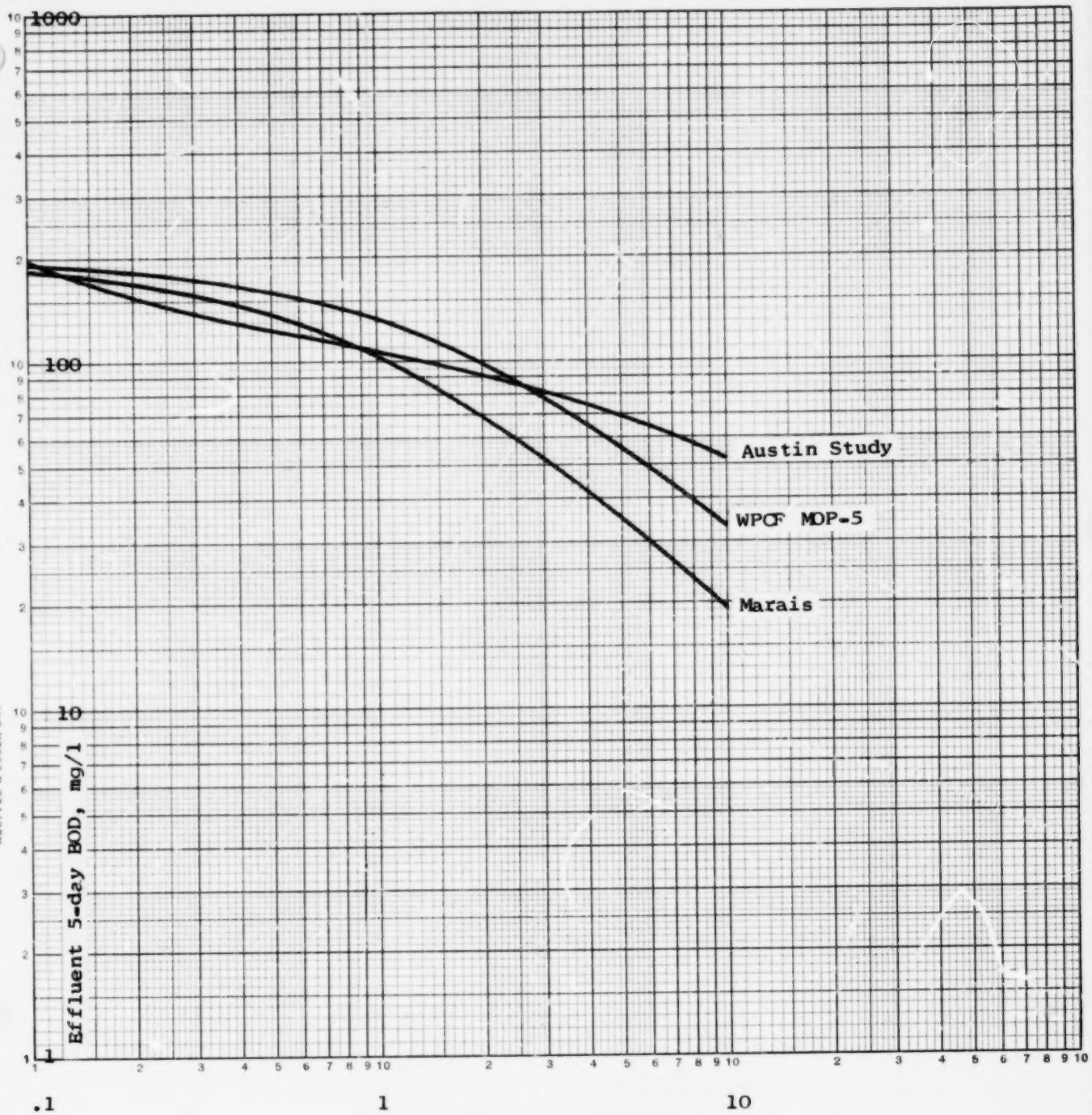
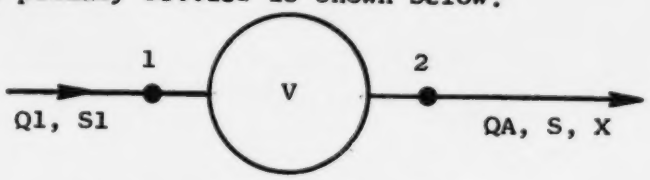


Figure 3A

APPENDIX II

The mass balance and rate equations used in developing the time dependent model for equalization basins are well known and simple in concept, but for the sake of clarity, these relationships will be developed here. A diagram of an equalization basin placed upstream of the primary settler is shown below:



The liquid volume in the equalization basin will vary diurnally to allow the flow out of the basin to be fixed at QA while the influent flow (Q1) varies sinusoidally. Mechanical aerators will be provided to supply the required dissolved oxygen.

The influent flow Q1 is assumed to vary sinusoidally according to the following relationship:

$$Q1 = QA - (QP - QA) \sin (2\pi t) \qquad (1A2)$$

QP = peak diurnal flow, mgd
QA = average diurnal flow, mgd
t = time, days

The mass balance for active solids around the equalization basin is written as follows:

$$d(VX)/dt = kXSV/(K+S) - bXV - QX \qquad (2A2)$$

V = liquid volume, mg
X = concentration of active solids, mg/l
S = concentration of substrate, mg/l BOD
Q = volume flow out of basin, QA, mgd
K = 150 mg/l BOD
k = maximum rate constant for snythesis, day^{-1}
b = endogenous respiration rate constant, day^{-1}
t = time in days

In the time dependent model, the following relationship was used to compute a function of loading, lb BOD applied per day per lb of

active solids in the basin:

$$L = \frac{Q1\ SL}{X\ V} \qquad (3A2)$$

$$k = (5.341 - 2.54 \log_e(1/L))/(150 + S) \qquad (4A2)$$

The BOD concentration (mg/l) in the raw wastewater was also assumed to vary sinusoidally according to the following relationship:

$$S1 = 200 - 133 \sin(2\pi t) \qquad (5A2)$$

t = time in days

Notice that the 24 hour composite measurement for BOD is not 200 mg/l but 200 mg/l plus (QP - QA)*(BODP - BODA)/2. Here BODP is the peak BOD value or 333 mg/l and BODA is the average BOD value or 200 mg/l. Therefore, at 1 mgd where QP is 1.78 mgd, the 24 hour composite value for BOD is 251.87 mg/l.

The mass balance for substrate can be written as follows:

$$d(VS)/dt = Q1\ S1 - QA\ S - kXSV/(CY(K+S)) \qquad (6A2)$$

CY = yield coefficient, lb. active mass/lb BOD synthesized

The rate at which the liquid volume of the basin varies is written simply as follows:

$$dV/dt = Q1 - QA \qquad (7A2)$$

To write the mass balance for dissolved oxygen, assume that 0.58 pounds of oxygen will be required for each pound of BOD synthesized and that 1.16 pounds of oxygen will be used for each pound of active solids destroyed by endogenous respiration. If we take EFF as the efficiency (lb-O_2/hp-hr) of mechanical aerators corrected to field conditions and take HP as the installed brake horsepower of the aerators, the amount of oxygen dissolved by the aerators is given as follows:

$$\text{Pounds } O_2 \text{ dissolved per day} = EFF\ HP\ 24 \qquad (8A2)$$

The mass balance for dissolved oxygen can now be expressed as follows:

$$d\,(VO)/dt = EFF\ HP\ 24/8.33 - .58kXSV/(CY(K+S)) - 1.16\ bXV - QA\ O \qquad (9A2)$$

O = dissolved oxygen concentration in basin, mg/l

In equations 2A2, 6A2, and 9A2, the left side can be expanded as follows:

$$d(VX)/dt = V\ dX/dt - X\ dV/dt \qquad (10A2)$$

Since we know that dV/dt is equal to (Q1 - QA) the equation can be readily solved for dX/dt.

APPENDIX III

The use of the FORTRAN mode of expression has several advantages. First, all expressions can be written using ordinary typewriter symbols on a single line. Second, ambiguity and misunderstanding can be avoided when the simple rules are understood. Third, when a computer program is being described, the variable names used in the digital computer program can be used thus making the computations performed better understood by the reader.

FORTRAN provides five basic operations: addition, subtraction, multiplication, division, and exponentiation. Each of the operations is represented by a distinct symbol as follows:

Addition	+
Subtraction	-
Multiplication	*
Division	/
Exponentiation	**

In writing FORTRAN expressions, using the operations shown above, the following rules must be observed:

1. Two symbols of operation must not appear next to each other. Thus, A*-B is not a valid expression but A*(-B) is valid.

2. Parentheses must be used to indicate groupings just as in ordinary mathematical notation. Thus, $(X+Y)^3$ must be written (X+Y)**3 to convey the correct meaning. Again, A-B+C and A-(B+C) are both legitimate expressions, but they do not mean the same thing.

3. When the hierarchy of operations in an expression is not completely specified by the use of parentheses, the sequence of operations is as follows: All exponentiations are performed first, then all multiplications and divisions, and finally all additions and subtractions.

4. When the order of consecutive multiplication and/or division or addition and/or subtraction is not specified by the use of parentheses, the operations are performed from left to right. Thus, A/B/C would be taken to mean A/(B*C) not (A*C)/B. Also, A-B+C would mean (A-B)+C not A-(B+C).

FORTRAN provides for the use of certain common mathematical functions, such as square root, logarithm, exponential, sine, cosine or absolute value of the variable X, and COSF(X) means the cosine of the angle X expressed as radians.

APPENDIX IV

DEFINITIONS FOR TIME DEPENDENT MODEL

S	Substrate concentration, 5-day BOD, mg/l
XA	Active mass, microorganisms, mg/l
DO	Dissolved oxygen concentration, mg/l
ALPHA	Aeration efficiency/aeration efficiency at standard conditions (.82)
BETA	Saturation DO value/saturation DO value at standard conditions (.90)
CAER2	Rate constant for synthesis at 20°C, day^{-1} (varies with load)
DAYS	Time for which numerical integration is performed, days
DMATX(16,N)	Excess capacity factor on usable volume, VU, mg (ECF) (1.25)
HPHRO	Mechanical aerator efficiency, lb O_2/hp-hr at standard conditions (3.5)
QA	Average daily flow into basin, mgd
RLW	Ratio of length to width for basin
AL	Altitude above sea level, ft.
TA	Ambient air temperature, °C (25°C)
TW	Influent stream water temperature, °C (20°C)
SPDO	Dissolved oxygen set point for DO control, mg/l (1.0)
TCI	Time constant for proportional control of DO, hp/(mg/l)
IPD	Integration intervals per day (100)
RP	Ambient air pressure/air pressure at sea level
QP	Peak diurnal influent flow, mgd
VU	Usable basin volume, cu. ft.
WIDTH	Basin width at water line, ft.
AREA	Basin area at water surface, acres

DEFINITIONS (Cont'd.)

VMIN	Minimum liquid volume for basin, cu. ft.
VUMG	Usable volume, mg
VOMG	Minimum volume, mg
VT	Total volume, mg
TL	Temperature of water in equalization basin, ^{o}C ($20.18^{o}C$)
SAREA	Area of lining required, sq. ft.
CY	Yield coefficient, dimensionless (.65)
CE	Endogenous respiration rate constant, $days^{-1}$ (.125)
CIA	ALPHA corrected for water temperature
DOTW	Saturation value for DO in tap water at TL
CSW	Saturation value for DO in basin, mg/l
H	Integration interval, days (.01)
Q2	Rate of flow out of basin, mgd
HP	Mechanical aerator brake horsepower
Q1	Instantaneous flow into basin, mgd
BODIN	Instantaneous BOD concentration into basin, mg/l
VDOT	Derivative of basin liquid volume with time, mg/days
XDOT	Derivative of active mass with time, (mg/l)/days
SDOT	Derivative of BOD remaining in basin with time, (mg/l)/days
EDO	Instantaneous DO control error, mg/l
Y	Average pounds of BOD out of basin per day
SOUT	Average concentration of BOD out of basin over 1 day
HPHRD	Horsepower-hours used in one day for mechanical aeration
X	Average pounds of BOD into basin per day
SIN	Average concentration of BOD into basin over 1 day
XY	Average pounds of active solids out per day
XOUT	Average concentration of active solids out over 1 day

TIME DEPENDENT PROGRAM FOR EQUALIZATION BASINS

```
C  EQUALIZATION BASIN PROGRAM  BY ROBERT SMITH AND ELLA HALL
      DIMENSION DMATX(16,10)
      IN=2
      IO=5
      READ(IN,11)  NCASE
      DO  500 ICASE=1,NCASE
    7 CONTINUE
      N=5
      XA=200.
      S=50.
      DO=1.0
      ALPHA=.82
      BETA=.9
      III=1
      Y=0.0
      X=0.0
      XY=0.0

      READ(IN,10)  CAER2,DAYS,DMATX(16,N),HPHRO,QA, RLW,AL,TA,TW,
     1SPOO,TC1
      READ(IN,11)  IPO

C     PRINT INPUT
    1 FORMAT(1H1,//,25X,'INPUT DATA',//,3X,'IPO',5X,'DAYS',7X,'ECF',7X,
     1'HPHRO',5X,'QA')
    2 FORMAT(2X,I5,4X,F5.0,5X,F5.2,6X,F5.2,5X,F5.0)
    3 FORMAT( 3X,F5.2,3X,F5.2,6X,F5.1,5X,F5.1,5X,F5.3,7X,F4.0,//)
    4 FORMAT(3X,'RLW',6X,'RP',9X,'TA',8X,'TW',7X,'CAER20',6X,'TC1')
    5 FORMAT(///,3X,'WIDTH',3X,'AREA',6X,'VMIN',7X,'VUMG',6X,'VOMG',8X,
     1'VT',7X,'SAREA')
    6 FORMAT(2X,F7.1,2X,F6.2,4X,F8.0,3X,F5.2,5X,F5.2,5X,F7.2,2X,F10.1,/)
   10 FORMAT(8F10.0)
   11 FORMAT(I3)
   14 FORMAT(1X,5F10.4,//)
   15 FORMAT(5X,'TL',8X,'CE',8X,          'CLA',7X,'DOTW',6X,'CSW',/)
   16 FORMAT(/5X,'Y=',F10.0,2X,'SOUT=',F10.2,5X,'HPHRO=',F10.4,5X,'X=',
     1F8.1,5X,'SIN=',F8.0,/,5X,'XY=',F8.0,5X,'XOUT=',F8.0,/)
      WRITE(IO,1)
      WRITE(IO,2)  IPO,DAYS,DMATX(16,N),HPHRO,QA
      WRITE(IO,4)
      RP=(760.-0.025 *AL)/760.
      WRITE(IO,3) RLW,RP,TA,TW,CAER2,TC1

      IDAY=DAYS-1.0
      QP=1.78*QA**.92
      VU=(QP-QA)/3.1416*1000000./7.48*DMATX(16,N)
      IF (VU-39000.)  20,20,25
```

```
   20 VU=39000.
      VMIN=1500.
      AREA=.18595
      WIDTH=90.
      GO TO 26
   25 WIDTH=(300.*(1.+RLW)+ (90000.*(1.+RLW)**2.-40.*RLW*
     1(12000.-VU))**.5)/20./RLW
      AREA=RLW*WIDTH**2./43560.
      VMIN=5.*RLW*WIDTH**2.-375.*WIDTH*(1.+RLW)+28500.
   26 CONTINUE
      VUMG=VU*7.48/1000000.
      VOMG=VMIN*7.48/1000000.
      VT=VUMG+VOMG
      RV=VT/VUMG
      TL=(8.34*QA*TW*1000000.+145.*AREA*43560.*(TA-2.))/(145.*AREA*
     243560.+8.34*QA*1000000.)
      SAREA=(2.*WIDTH*(1.+RLW)-156.)*53.76+(WIDTH-90.)*(RLW*WIDTH-90.)+
     120.*(24.+(1.+RLW)*WIDTH)
      CY=.65
      CE=.18*(1.047)**(TL-28.)
      CLA=ALPHA*1.025**(TL-20.)
      DOTW=14.652-.41022*TL+.0079910*TL**2.-.000077774*TL**3.
      CSW=BETA*DOTW*RP
      H=1./IPD
      Q2=QA
      NIC=DAYS*100.
      V=VT
      IF (VT-1.4)  18,18,30
   30 HP=29.88*VT
      GO TO 19
   18 HP=VT*35.36/(VT**.5)
   19 CONTINUE
      WRITE(IO,15)
      WRITE(IO,14)  TL,CE,CLA,DOTW,CSW
      WRITE(IO,5)
      WRITE(IO,6)  WIDTH,AREA,VMIN,VUMG,VOMG,VT,SAREA
      WRITE(IO,49)


C     AERATION LOOP
      IPRT=4
      T=0.
      DO 100 NI=1,NIC
      IPRT=IPRT+1
      Q2=QA
      Q1=QA-(QP-QA)*FSIN(6.283*T)
      BODIN=200.-133.*FSIN(6.283*T)
      XLOAD=(Q1*BODIN)/(XA*V)
      CAER2=(5.341-2.540*ALOG(1./XLOAD))/(150.+S)
      CS=CAER2*(1.08)**(TL-20.)
      VDOT=Q1-Q2
      XDOT=CS*XA*S-XA*Q2/V-CE*XA-XA*(Q1-Q2)
      SDOT=BODIN*Q1/V-CS*XA*S/CY-Q2*S/V-S*(Q1-Q2)/V
      A1=HP*HPHRD*CLA*24./9.02/8.33/V
      A2=.58*CS*XA*S/CY+1.16*CE*XA
      A3=A1*CSW-A2
      A4=A1+Q1/V
      DO=A3/A4-(A3/A4-DO)/2.71828**(A4*H)
      IF (DO)  46,46,47
```

```
   46 DO=0.0
      GO TO 48
   47 CONTINUE
   48 EDO=SPDO-DO
      HP=HP+TC1*EDO
      IF (HP)  27,28,28
   27 HP=1.0
   28 CONTINUE
      V=V+VDOT*H
      XA=XA+XDOT*H
      S=S+SDOT*H
      DELS=Q2*S*8.33
      DELX=Q1*BODIN*8.33
      DELXY=Q2*XA*8.33
      IF(III-101) 690,670,670
  670 III=1
      XOUT=XY/Q2/8.33
      SOUT=Y/Q2/8.33
      SSIN=X/QA/8.33
      WRITE(IO,16)  Y,SOUT,HPHRD,X,SSIN,XY,XOUT
      XY=0.0
      X=0.0
      Y=0.0
      HPHRD=0.0
  690 Y=Y+DELS*H
      X=X+DELX*H
      XY=XY+DELXY*H
      HPHRD=HPHRD+HP*24.*H
      III=III+1
      T=T+H

   49 FORMAT(10X,'T',10X,'V',10X,'XA',11X,'S',11X,'DO',11X,'Q1',10X,'HP'
     1,6X,'CS',6X,'BODIN',/)
   50 FORMAT(3X,7(F10.2,2X),F8.4,2X,F8.3)
      IF(IPRT-5)  100,51,100
   51 CONTINUE
      WRITE(IO,50)  T,V,XA,S,DO,Q1,HP,CS,BODIN
      IPRT=0
      IF(T-14.0)  100,7,7
  100 CONTINUE
  500 CONTINUE
      CALL EXIT
      END
```

```
   46 DD=0.0
      GO TO 48
   47 CONTINUE
   48 EDD=SPDD-DD
      HP=HP+TC1*EDD
      IF (HP)  27,28,28
   27 HP=1.0
   28 CONTINUE
      V=V+VDOT*H
      XA=XA+XDOT*H
      S=S+SDOT*H
      DELS=G2*S*8.33
      DELX=G1*BODIN*8.33
      DELXY=G2*XA*8.33
      IF(III-.01) 690,670,670
  670 III=1
      XOUT=XY/G2/8.33
      SOUT=Y/G2/8.33
      SSIN=X/GA/8.33
      WRITE(IO,10)  Y,SOUT,HPHRD,X,SSIN,XY,XOUT
      XY=0.0
      X=0.0
      Y=0.0
      HPHRD=0.0
  690 Y=Y+DELS*H
      X=X+DELX*H
      XY=XY+DELXY*H
      HPHRD=HPHRD+HP*24.*H
      III=III+1
      T=T+H

   49 FORMAT(10X,'T',10X,'V',10X,'XA',11X,'S',11X,'DD',11X,'G1',10X,'HP'
     1,6X,'GS',5X,'BODIN',/)
   50 FORMAT(3X,7(F10.2,2X),F8.4,2X,F8.3)
      IF(IPRT-5)  100,51,100
   51 CONTINUE
      WRITE(IO,50)  T,V,XA,S,DD,G1,HP,GS,BODIN
      IPRT=0
      IF(T-10.0)  100,7,7
  100 CONTINUE
  500 CONTINUE
      CALL EXIT
      END
```

39-a

INPUT DATA

IPD	DAYS	ECF	HPHRC	QA		
100	28.	1.25	3.50	10.		
RLW	RP	TA	TW	CAER20	TCI	
1.00	1.00	25.0	20.0	0.143	30.	

TL	CE	CLA	DOTW	CSW
20.1753	0.1256	0.8235	8.9896	8.0906

WIDTH	AREA	VMIN	VUMG	VCMG	VT	SAREA
188.9	0.81	65284.	1.91	0.48	2.40.	50069.0

T	V	XA	S	DO	QI	HP	CS	BODIN
12.00	2.40	39.02	211.59	0.98	10.04	101.96	0.0365	201.142
12.05	2.35	46.86	183.80	1.01	8.55	101.50	0.0352	159.998
12.10	2.24	56.34	155.00	1.06	7.20	94.64	0.0337	122.765
12.15	2.07	66.78	127.20	1.09	6.13	82.12	0.0322	93.091
12.20	1.85	76.86	101.89	1.09	5.44	67.59	0.0314	73.878
12.25	1.61	84.54	79.88	1.07	5.19	55.24	0.0332	67.005
12.30	1.38	87.21	62.12	1.06	5.41	45.53	0.0389	73.146
12.35	1.17	82.43	51.46	1.04	6.08	37.52	0.0482	91.698
12.40	1.00	70.21	52.75	1.01	7.14	33.07	0.0580	120.849
12.45	0.90	54.72	70.09	0.99	8.47	32.74	0.0637	157.745
12.50	0.87	41.17	103.40	0.98	9.95	34.12	0.0634	198.773
12.55	0.91	31.87	146.25	0.98	11.44	36.20	0.0592	239.923
12.60	1.02	26.39	189.19	0.97	12.78	39.66	0.0542	277.167
12.65	1.19	23.55	225.32	0.95	13.86	45.01	0.0497	306.860
12.70	1.41	22.41	251.63	0.94	14.55	52.20	0.0462	326.095
12.75	1.65	22.44	267.34	0.93	14.80	60.83	0.0435	332.994
12.80	1.88	23.43	272.71	0.93	14.58	70.36	0.0415	326.878
12.85	2.09	25.40	268.50	0.93	13.91	80.19	0.0400	308.348
12.90	2.26	28.48	255.88	0.94	12.86	89.55	0.0387	279.216
12.95	2.36	32.93	236.36	0.95	11.52	97.32	0.0376	242.332

Y= 13796. SCUT= 165.62 HPHRD= 1508.9172 X= 19322.2 SIN= 231.
XY= 3928. XCUT= 47.

```
C  EQUALIZATION BASIN PROGRAM  BY ROBERT SMITH AND ELLA
      DIMENSION DMATX(16,10)
      IN=2
      IO=5
      READ(IN,11)  NCASE
      DO  500 ICASE=1,NCASE
    7 CONTINUE
      N=5
      QA=200.
      S=50.
      DC=1.0
      ALPHA=.82
      BETA=.9
      III=1
      Y=0.0
      X=0.0
      XY=0.0

      READ(IN,10)  CAER2,DAYS,DMATX(16,N),HPHRO,QA, RLW,AL,TA,TW,
     1SPGC,TC1
      READ(IN,11)  IPD

C     PRINT INPUT
    1 FORMAT(1H1,//,25X,'INPUT DATA',//,3X,'IPD',5X,'DAYS',7X,'ECF',7X,
     1'HPHRO',5X,'QA')
    2 FORMAT(2X,I5,4X,F5.0,5X,F5.2,6X,F5.2,5X,F5.0)
    3 FORMAT( 3X,F5.2,3X,F5.2,6X,F5.1,5X,F5.1,5X,F5.3,7X,F4.0,//)
    4 FORMAT(3X,'RLW',6X,'RP',9X,'TA',8X,'TW',7X,'CAER20',6X,'TC1')
    5 FORMAT(///,3X,'WIDTH',3X,'AREA',6X,'VMIN',7X,'VUMG',6X,'VOMG',8X,
     1'VT',7X,'SAREA')
    6 FORMAT(2X,F7.1,2X,F6.2,4X,F8.0,3X,F5.2,5X,F5.2,5X,F7.2,2X,F10.1,/)
   10 FORMAT(8F10.0)
   11 FORMAT(I3)
   14 FORMAT(1X,5F10.4,//)
   15 FORMAT(5X,'TL',8X,'CE',8X,        'CLA',7X,'DOTW',6X,'CSW',/)
   16 FORMAT(/5X,'Y=',F10.0,2X,'SOUT=',F10.2,5X,'HPHRD=',F10.4,5X,'X=',
     1F8.1,5X,'SIN=',F8.0,/,5X,'XY=',F8.0,5X,'XOUT=',F8.0,/)
      WRITE(IO,1)
      WRITE(IO,2)  IPD,DAYS,DMATX(16,N),HPHRO,QA
      WRITE(IO,4)
      RP=(760.-0.025 *AL)/760.
      WRITE(IO,3) RLW,RP,TA,TW,CAER2,TC1

      IDAY=DAYS-1.0
      CP=1.78*QA**.92
      VU=(CP-QA)/3.1416*1000000./7.48*DMATX(16,N)
      IF (VU-39000.)  20,20,25
```

P-04

EXECUTIVE PROGRAM
EQUALIZATION POND SUBROUTINE (EQUAL)
DECISION AND OUTPUT MATRIX PARAMETERS

DMATX

DMATX(1,N) = IAER, program control: 0 = small impeller mechanical aerators on floating platforms are used, 1 = large impeller mechanical aerators on stationary platforms are used

DMATX(2,N) = RLW, ratio of length to width for the equalization basin

DMATX(3,N) = COSTL, cost of pond lining material, dollars/sq ft

DMATX(4,N) = HEAD, pumping head of effluent pumps from the equalization pond process, feet

DMATX(14,N) = ECF, excess capacity factor (pumping system)

DMATX(15,N) = ECF, excess capacity factor (surface aerators)

DMATX(16,N) = ECF, excess capacity factor (equalization pond)

OMATX

OMATX(1,N) = WIDTH, equalization basin width at the water line, feet

OMATX(2,N) = AREA, equalization basin area at the water surface, acres

OMATX(3,N) = VUMG, usable liquid volume for the equalization basin, mg

OMATX(4,N) = VOMG, minimum liquid volume for the equalization basin, mg

OMATX(5,N) = VT, total liquid volume of the equalization basin (VUMG + VOMG), mg

OMATX(6,N) = SAREA, area of equalization basin lining required, sq ft

OMATX(7,N) = HP, mechanical aerator brake horsepower, hp

OMATX(8,N) = HP1, brake horsepower (HP) rounded off to the next higher available size mechanical aerator, hp

OMATX(9,N) = XN, number of mechanical aerators required

OMATX(10,N) = THP, total mechanical aeration brake horsepower required (HP1*XN), hp

OMATX(11,N) = PLAND, amount of land needed for the equalization basin, acres (Note that this land area requirement is included in the total land area requirement (ACRE) for the whole plant)

OMATX(12,N) = CLAND, cost of land needed for the equalization basin, dollars (Note that this cost is included in the total plant cost (XLAND) for land)

```
      SUBROUTINE EQUAL
      INTEGER OS1,OS2
      DIMENSION SIZE(14)
      COMMON SMATX(20,25),TMATX(20,25),DMATX(20,20),OMATX(20,20),IP(25),
     . INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),
     . ACOST(20,5),TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND
      DATA SIZE/5.,7.5,10.,15.,20.,25.,30.,40.,50.,60.,75.,100.,
     . 125.,150./
      VAER=0.
      ECFM=0.
      PLAND=0.
      CLAND=0.
      HP=0.
      HP1=0.
      XN=0.
      THP=0.
      IAER=DMATX(1,N)
      RLW=DMATX(2,N)
      COSTL=DMATX(3,N)
      HEAD=DMATX(4,N)
      IMAT=DMATX(5,N)
      QP=1.78*SMATX(2,IS1)**.92
      VU=SMATX(2,IS1)*.12*1000000./7.48*DMATX(16,N)
      IF(IMAT) 25,5,25
    5 IF(VU-39000.) 10,10,20
   10 VU=39000.
      WIDTH=90.
      AREA=.18595
      VMIN=1500.
      SAREA=(2.*WIDTH*(1.+RLW)-156.)*53.76+(WIDTH-90.)*(RLW*WIDTH-90.)+
     . 20.*(24.+(1.+RLW)*WIDTH)
      GO TO 30
   20 WIDTH=(300.*(1.+RLW)+(90000.*(1.+RLW)**2.-40.*RLW*(12000.-VU))
     . **.5)/20./RLW
      AREA=RLW*WIDTH**2./43560.
      VMIN=5.*RLW*WIDTH**2.-375.*WIDTH*(1.+RLW)+28500.
      SAREA=(2.*WIDTH*(1.+RLW)-156.)*53.76+(WIDTH-90.)*(RLW*WIDTH-90.)+
     . 20.*(24.+(1.+RLW)*WIDTH)
      GO TO 30
   25 WIDTH=(300.*(1.+RLW)+(90000.*(1.+RLW)**2.-40.*RLW*(12000.-VU))
     . **.5)/20./RLW
      AREA=RLW*WIDTH**2./43560.
      VMIN=VU*.2857
      SAREA=0.
   30 VUMG=VU*7.48/1000000.
      VOMG=VMIN*7.48/1000000.
      VT=VUMG+VOMG
      IF(IMAT) 92,35,92
   35 IF(VT-1.4) 50,50,40
   40 HPA=VT*29.88
      GO TO 60
   50 HPA=VT*35.36/(VT**.5)
   60 HPB=VT*59./(VT**.4254)
      IF(HPA-HPB) 62,64,64
   62 HP=HPB*DMATX(15,N)
      GO TO 66
   64 HP=HPA*DMATX(15,N)
   66 DO 80 I=1,14
      IF(HP-SIZE(I)) 70,70,80
```

```
   70 HP1=SIZE(I)
      XN=1
      GO TO 90
   80 CONTINUE
      HP1=150.
      XN=HP/150.
      IXN=XN
      XN=IXN+1
   90 THP=HP1*XN
   92 X=ALOG(SMATX(2,IS1)*DMATX(14,N))
      CCOST(N,3)=EXP(3.481553+.377485*X+.093349*X**2.-.006222*X**3.)*
     . 1000.
      X=ALOG(SMATX(2,IS1))
      OHRS=EXP(6.097269+.253066*X-.193659*X**2.+.078201*X**3.-
     . .006680*X**4.)
      XMHRS=EXP(5.911541-.013158*X+.076643*X**2.)
      E12=EXP(6.799199+.785690*X-.087865*X**2.+.042646*X**3.-
     . .004488*X**4.)*HEAD/30.
      S12=EXP(5.851743+.301610*X+.197183*X**2.-.017962*X**3.)
      TMSU=E12+S12
      CCSTC(N,3)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.
      X=ALOG(SMATX(2,IS1)*DMATX(14,N))
      CCOST(N,4)=EXP(8.109253+.646743*X)
      COSTC(N,4)=0.
      IF(IMAT) 95,100,95
   95 VOMG=0.
      VT=VOMG
      VAER=VT*1000./7.48
      X=ALOG(VAER)
      CCOST(N,1)=EXP(2.414380+.175682*X+.084742*X**2.-.002670*X**3.)*
     . 1000.
      CCSTC(N,1)=0.
      ECFM=20.*VAER*DMATX(15,N)
      X=ALOG(ECFM/1000.)
      CCOST(N,2)=EXP(4.145454+.633339*X+.031939*X**2.-.002419*X**3.)*
     . 1000.
      X=ALOG(ECFM/1000./DMATX(15,N))
      OHRS=EXP(6.900586+.323725*X+.059093*X**2.-.004926*X**3.)
      XMHRS=EXP(6.169937+.294853*X+.175999*X**2.-.040947*X**3.+
     . .003300*X**4.)
      EHP=ECFM/DMATX(15,N)*8.1*144./(33000.*.8)
      XKW=.8*EHP
      XKWPY=XKW*24.*365.
      ECOST=XKWPY*DMATX(10,20)
      SCOST=EXP(.621382+.482047*X)*1000.
      TMSU=ECOST+SCOST
      COSTC(N,2)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.
      GO TO 190
  100 X=ALOG(AREA)
      IF(AREA-1.) 105,110,110
  105 CCOST(N,1)=22000.
      OHRS=600.
      XMHRS=100.
      GO TO 120
  110 CCOST(N,1)=EXP(3.501091+.422086*X+.079097*X**2.-.008338*X**3.)*
     . 1000.
      OHRS=EXP(6.547042+.262634*X+.058298*X**2.-.013454*X**3.+
     . .001494*X**4.)
      XMHRS=EXP(4.844423+.327982*X+.017677*X**2.)
```

```
120 TMSU=0.
    COSTO(N,1)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.
    X=ALOG(THP)
    IF(IAER) 140,130,140
130 CCOST(N,2)=EXP(.647120+.438812*X+.031192*X**2.)*1000.
    GO TO 150
140 CCOST(N,2)=EXP(3.141014-.218751*X+.136739*X**2.-.006042*X**3.)*
   . 1000.
150 X=ALOG(THP/DMATX(15,N))
    OHRS=0.
    XMHRS=0.
    XKW=.8*THP/DMATX(15,N)
    XKWPY=XKW*24.*365.
    ECOST=XKWPY*DMATX(10,20)
    SCOST=EXP(4.016957+.534211*X)
    TMSU=ECOST+SCOST
    COSTO(N,2)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.
    CCOST(N,5)=SAREA*COSTL
    COSTO(N,5)=0.
    X=ALOG(AREA)
    PLAND=EXP(1.588306+.529246*X+.038611*X**2.)
    CLAND=PLAND*DMATX(7,20)
190 DO 200 I=2,17
200 SMATX(I,OS1)=SMATX(I,IS1)
    DMATX(1,N)=WIDTH
    DMATX(2,N)=AREA
    DMATX(3,N)=VOMG
    DMATX(4,N)=VOMG
    DMATX(5,N)=VT
    DMATX(6,N)=SAREA
    DMATX(7,N)=HP
    DMATX(8,N)=HP1
    DMATX(9,N)=XN
    DMATX(10,N)=THP
    DMATX(11,N)=PLAND
    DMATX(12,N)=CLAND
    DMATX(13,N)=VAER
    DMATX(14,N)=ECFM
    RETURN
    END
```

EXECUTIVE
DIGITAL COMPUTER PROGRAM
FOR
PRELIMINARY DESIGN OF WASTEWATER TREATMENT SYSTEMS

BY
ROBERT SMITH
RICHARD G. EILERS

U.S. ENVIRONMENTAL PROTECTION AGENCY
ADVANCED WASTE TREATMENT RESEARCH LABORATORY
CINCINNATI, OHIO

10 MGD TEST OF EQUALIZATION POND FEBRUARY 1973 SBEDS

SYSTEM DIAGRAM
INPUT DATA

K	N	PROCESS		IS1	IS2	CS1	CS2	III
0	1	20	EQUAL	1	0	2	0	2
1	0	4	MIX	2	19	20	0	1
0	8	2	PRSET	20	0	3	21	0
0	2	3	AERFS	3	0	4	7	0
0	0	5	SPLIT	4	0	5	8	0
0	0	4	MIX	21	7	22	0	0
0	3	8	THICK	22	8	9	12	0
0	4	6	DIG	9	0	10	0	0
0	5	10	SBEDS	10	0	11	13	0
1	0	4	MIX	12	13	19	0	1
0	6	12	CHLOR	5	0	25	0	2
9	0	0		0	0	0	0	0

STREAM CHARACTERISTICS

VOLUME FLOW, MILLIONS OF GALLONS PER DAY
CONCENTRATIONS, MILLIGRAMS PER LITER

S 1.	Q	SCC	SNBC	SON	SOP	SFM	SBOD	VSS
	10.000	105.000	30.000	10.000	2.000	30.000	140.200	223.600
	ALK	DCC	DNBC	DN	DP	DFM	DBOD	TSS
	250.000	43.000	11.000	19.100	4.000	500.000	59.840	253.600
S 2.	Q	SCC	SNBC	SON	SOP	SFM	SBOD	VSS
	10.000	105.000	30.000	10.000	2.000	30.000	140.200	223.600
	ALK	DCC	DNBC	DN	DP	DFM	DBOD	TSS
	250.000	43.000	11.000	19.100	4.000	500.000	59.840	253.600
S 3.	Q	SCC	SNBC	SON	SOP	SFM	SBOD	VSS
	11.819	46.543	13.410	4.484	0.877	13.346	61.989	99.361
	ALK	DCC	DNBC	DN	DP	DFM	DBOD	TSS
	266.837	39.013	11.000	23.496	4.989	500.000	52.385	112.707
S 4.	Q	SCC	SNBC	SON	SOP	SFM	SBOD	VSS
	11.703	5.844	2.231	0.867	0.058	1.853	7.084	13.908
	ALK	DCC	DNBC	DN	DP	DFM	DBOD	TSS
	266.837	14.165	11.000	21.735	5.446	500.000	5.918	15.762
S 5.	Q	SCC	SNBC	SON	SOP	SFM	SBOD	VSS
	9.999	5.844	2.231	0.867	0.058	1.853	7.084	13.908
	ALK	DCC	DNBC	DN	DP	DFM	DBOD	TSS
	266.837	14.165	11.000	21.735	5.446	500.000	5.918	15.762
S 7.	Q	SCC	SNBC	SON	SOP	SFM	SBOD	VSS
	0.115	3715.369	1418.654	551.335	37.153	1178.316	4503.731	8842.578
	ALK	DCC	DNBC	DN	DP	DFM	DBOD	TSS
	266.837	14.165	11.000	21.735	5.446	500.000	5.918	10020.892
S 8.	Q	SCC	SNBC	SON	SOP	SFM	SBOD	VSS
	1.703	5.844	2.231	0.867	0.058	1.853	7.084	13.908
	ALK	DCC	DNBC	DN	DP	DFM	DBOD	TSS
	266.837	14.165	11.000	21.735	5.446	500.000	5.918	15.762
S 9.	Q	SCC	SNBC	SON	SOP	SFM	SBOD	VSS
	0.047	19655.054	6480.667	2347.670	293.406	5901.291	25133.984	44098.718
	ALK	DCC	DNBC	DN	DP	DFM	DBOD	TSS
	266.837	14.365	10.999	21.749	5.443	499.999	6.293	50000.007
S10.	Q	SCC	SNBC	SON	SOP	SFM	SBOD	VSS
	0.047	6825.775	6480.667	829.743	103.699	5901.291	645.352	16245.341
	ALK	DCC	DNBC	DN	DP	DFM	DBOD	TSS
	3789.187	126.036	10.999	1008.402	195.150	499.999	215.117	22146.632

S11.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
S12.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
	1.786	27.688	9.129	3.307	0.413	8.313	35.406	62.121
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
	266.837	14.365	10.999	21.749	5.443	499.999	6.293	70.434
S13.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
	0.047	15.410	14.631	1.873	0.234	13.323	1.456	36.676
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
	3789.187	126.036	10.999	1008.402	195.150	499.999	215.117	50.000
S19.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
	1.833	27.367	9.272	3.269	0.408	8.443	34.521	61.458
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
	358.656	17.276	10.999	47.469	10.388	499.999	11.737	69.902
S20.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
	11.833	92.969	26.788	8.957	1.753	26.659	123.823	198.473
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
	266.837	39.013	11.000	23.496	4.989	500.000	52.385	225.133
S21.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
	0.014	37187.898	10715.201	3582.821	701.358	10663.814	49529.390	79389.500
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
	266.837	39.013	11.000	23.496	4.989	500.000	52.385	90053.312
S22.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
	0.130	7516.676	2474.416	895.606	112.584	2255.537	9617.070	16854.238
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
	266.837	16.987	10.999	21.935	5.395	499.999	11.195	19109.773
S25.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS
	9.999	5.844	2.231	0.867	0.058	1.853	7.084	13.908
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
	266.837	14.165	11.000	21.735	5.446	500.000	5.918	15.762

PROCESS CHARACTERISTICS

CCOST = CAPITAL COST, DOLLARS
COSTO = OPERATING + MAINTENANCE COST, CENTS/1000 GAL.
ACOST = AMORTIZATION COST, CENTS/1000 GAL.
TCOST = TOTAL TREATMENT COST, CENTS/1000 GAL.

P 1 EQUALIZATION

IAER	RLK	COSTL	HEAD	IMAT	WIDTH	AREA	VOMG	VOMG	VT
1.0	1.0	0.500	10.0	0.0	170.54	0.6677	1.5000	0.3442	1.8442
SAREA	HP	HP1	XN	THP	PLAND	CLAND	VAER	ECFM	
42077.4	83.86	100.00	1.0	100.00	3.97	3978.	0.000	0.	

	CCOST	COSTO	ACOST	TCOST	ECF
AERATED POND/TANK	29645.	0.077	0.063	0.140	1.25
AIR SUPPLY	114629.	0.267	0.245	0.513	1.00
PUMPING SYSTEM	158853.	0.217	0.340	0.557	1.00
FLOW MEASURING	19864.	0.000	0.042	0.042	
POND LINING	28350.	0.000	0.060	0.060	

P 2 AERATOR-FINAL SETTLER

BOD	MLSS	DEGC	CAER20	DO	AEFF20	URSS	GSS	HEAD	
13.0	2000.	20.00	1.00	1.00	0.05	5.00	700.00	30.00	
BOD2	DOSAT	XRSS	AFS	CAER	CEDR	VAER	VNIT	MLASS	MLBSS
114.3	10.7	0.0078	24.41	1.00	0.124	2.188	2.640	660.	560.
MLNBSS	MLDSS	MLISS	FOOD	RTURN	CNIT	ARCFD	BSIZE	CFPGL	QR
504.	43.	235.	78.0	0.235	0.321	7553135.	5245.	0.63	2.787

	CCOST	COSTO	ACOST	TCOST	ECF
AERATOR	385400.	0.000	0.825	0.825	1.14
BLOWER	262455.	1.025	0.562	1.588	1.00
SLUDGE PUMPS	70681.	0.167	0.151	0.318	1.00
FINAL SETTLER	391369.	0.347	0.838	1.186	1.17

P 3 GRAVITY THICKENER

TRR	TSS	GTH	GSTH	ATHM	WRT				
0.95	50000.	700.0	8.0	3929.6	13.07				
					CCOST	COSTO	ACOST	TCOST	ECF
					110407.	0.099	0.236	0.336	1.50

P 4 ANAEROBIC DIGESTER

TD	TDIG	C1DIG	C2DIG	VDIG	CH4	CO2			
15.0	30.0	0.233	1154.	127.	99611.	52313.			
					CCOST	COSTO	ACOST	TCOST	ECF
					369974.	0.262	0.792	1.055	1.33

P 5	SLUDGE DRYING BEDS	SBL 0.007786	SOUT 0.35	TSS 50.	ASB 238845.		CCOST 351262.	COSTO 0.792	ACOST 0.752	TCOST 1.544	ECF 1.00
P 6	CHLORINATION	DCL2 8.0	TCL2 30.0			FEED SYSTEM	CCOST 75696.	COSTO 0.599	ACOST 0.162	TCOST 0.761	ECF 1.00
						CONTACT BASIN	67102.	0.000	0.143	0.143	1.00
P 8	PRIMARY SETTLER	FRPS 0.50	URPS 400.0	HPWK 14.0	GPS 1375.2	APS 10.067	PGPM 123.				
						SETTLER	CCOST 201904.	COSTO 0.195	ACOST 0.432	TCOST 0.628	ECF 1.17
						SLUDGE PUMPS	63366.	0.218	0.135	0.354	1.00
	ADMINISTRATIVE AND LABORATORY						CCOST 149339.	COSTO 0.410	ACOST 0.320	TCOST 0.730	
	GARAGE AND SHOP						CCOST 44194.	COSTO 0.000	ACOST 0.094	TCOST 0.094	
	LABORATORY OPERATION	XLAB 1.0					CCOST 0.	COSTO 0.473	ACOST 0.000	TCOST 0.473	
	YARDWORK OPERATION						CCOST 0.	COSTO 0.257	ACOST 0.000	TCOST 0.257	

TOTAL PLANT COST

TOTAL CAPITAL COST = 2894496. DOLLARS

TOTAL AMORTIZATION COST = 6.203 CENTS/1000 GAL.

TOTAL C + M COST = 5.411 CENTS/1000 GAL.

TOTAL TREATMENT COST = 11.614 CENTS/1000 GAL.

CCI	WPI	RI	YRS	OHR	PCT	DA	CCINT	XLAB	CKWH
1.506	1.122	0.060	25.0	3.50	0.150	1000.	0.06	1.00	0.013

RATIO	TCAP	YARD	TCC	XLAND	ENG	SUBT1	FISC	SUBT2	XINT
1.347	2148011.	300721.	2448727.	23955.	236221.	2708902.	25858.	2734761.	159729.

ACRE	AF
23.95	0.07822